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FABRICATION AND PROPERTIES EVALUATION OF CNT POLYMER COMPOSITES

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ABSTRACT

In polymer and metal matrix composites that form a strong bond between the fiber and the matrix, the matrix transmits loads from the matrix to the fibers through shear loading at the interface. In component designing, the rapid prototyping technique is utilized to make a 3-D model of an item or part. To extract samples of polymer mix composite recent trends of 3D rapid prototyping machine has been used. The phenomenon of samples preparation is layer depositing also discussed, keeping in mind the end goal to prepare composite filled and carbon material in various structures, Carbon NANO Tube (CNT) item (UPNT) what brought into PP matrix however so Carbon Black (CB) and financially accessible CNT (CN) were utilized. The composite mixing and extrusion percentages are given in terms of volume percentage basis. In the present research two materials PP and ABS taken as polymer materials and minute percentages of 0.1 and 0.2 of CNT mixed. The properties of samples were tested for application sustainability.

***KEYWORDS:** Polymer CNT matrix, Rapid prototyping & Mechanical and thermal properties evaluation.*

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Original Article

INTRODUCTION

Polymer Matrix Composite (PMC) is divided into two categories: Reinforced plastics and advanced composites. The distinction is based on the level of mechanical properties (usually strength and stiffness); however, there is no unambiguous line separating the two.

Reinforced plastics are relatively inexpensive; typically consist of polyester resins reinforced with low-stiffness glass fibers (E-glass). They have been in use for 30 to 40 years in applications such as boat hulls, corrugated sheet, pipe, automotive panels, and sporting goods.

The process belongs to the generative (or additive) production processes unlike subtractive or forming processes such as lathing, milling, grinding or coining etc. in which form is shaped by material removal or plastic deformation.. In all commercial RP processes, the part is fabricated by deposition of layers contoured in a (x-y) plane two dimensionally. The third dimension (z) results from single layers are being stacked up on top of each other, but not as a continuous z-coordinate.

Albrecht Leonhardt (2005) [1] in his research, he explains about melt mixing as method to disperse carbon NANO tubes into thermoplastic polymers. In this system, electrical percolation was found at about 0.5 wt% MWCNT. [4-7]The incorporation of NANO tubes significantly changes the stress-strain behavior of the composites and thereby the thermal & mechanical properties are enhanced. Modulus and stress are enhanced; however, the elongation at break is reduced, especially above the percolation concentration-H. Du, J. Bai, H- M. Cheng [2]

concluded key problems, such as how to prepare structure controllable CNTs with high purity and consistently dependable, high performance, [8-12] how to break up bundled to reinforcement of CNTs and then uniformly disperse and align them within a polymer matrix, how to improve the load transfer from the matrix to CNT reinforcement. H. DJOUDI [3]

Twin-screw mixer (injection molding process) was employed for preparing polypropylene (PP) NANO composites loaded at 2, 5, and 10 wt% of MWCNT. Characterization of the rheological behavior of polypropylene as well as polypropylene/multi-walled carbon NANO tube mixtures, at three temperatures (180, 200, and 220 °C,) A proper agreement between numerical simulation and experimental results concerning mixing torque and mixing index as well as temperature fields has been obtained.

Therefore, the prototypes are very exact on the x-y plane, but have stair-stepping effect in z-direction. If the model is deposited with very fine layers, i.e., smaller z-stepping, model looks like original. RP can be classified into two fundamental process steps namely generation of mathematical layer information and generation of physical layer model. Typical process chain of various RP systems flow chart is shown in figure.1.

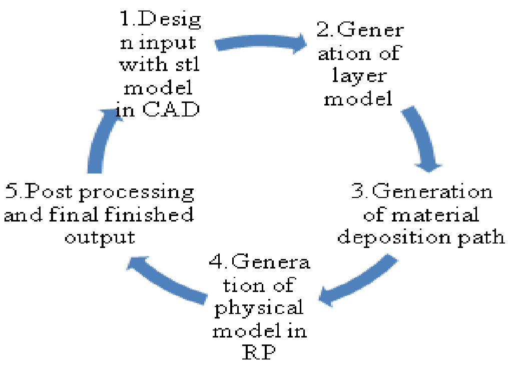

Figure1: RP Process Chain Showing Fundamental Process Steps

SCOPE OF WORK

In the above mentioned molecular studies, the effect of CNT reinforcements on mechanical properties of polymer composites has been investigated. However, mechanical properties reported in the studies are scattered and may not be directly used in a continuum-based framework for design purposes as some effects are still obscure such as the geometries of CNTs. The major reason for the inapplicability of the results in a continuum framework is because the interfacial separation and sliding between reinforcements and matrices owing to the weakened bonding formed between CNTs and polymer matrices have not been accounted systematically. As a result, the contribution of the interfacial region on the overall mechanical properties of CNT/polymer composites cannot be addressed in the framework for future designs.

OBJECTIVE AND MOTIVATION

Continuous phase preparation of polymer matrix composites is a process of preparing high accurate products in polymers. The preparation of carbon polymers may be best applied and it is also an advanced technique for present scenarios. Even though many researches advancing in polymer preparation of carbons advanced interpretation of NANO's includes with local available polymers has become a major task because of its minute particle size. This study can give a scope of fabrication of CNT's with local polymers like PP, ABS.

METHODOLOGY AND PRACTICAL APPROACH

Injection and layer forming method (RP): Injection layer forming method is a prominent process of rapid prototyping where minute particles heated up to the liquidation temperature and the model formed by CNC technique.

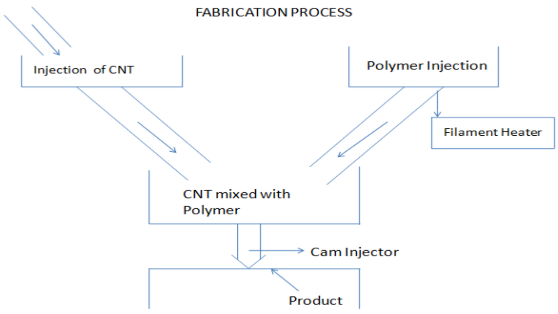

Figure 2: The Layout of the Extrusion Process

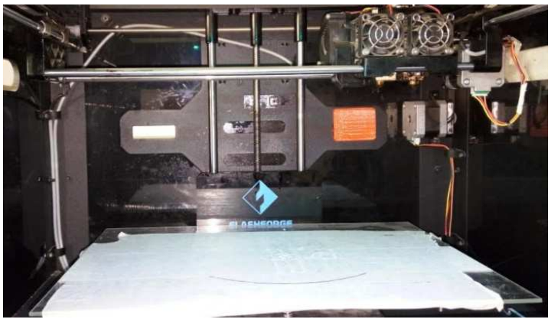

Figure 3: Rapid Prototyping System

CAD Modeling

It is necessary for 3D prototyping material depositing method to get an optimal deposition along the flow line for better bonding applications. CAD diagrams of tube layout, material deposition layout and material deposition layers layout are presented in Figure.4, Figure.5 and Figure.6 respectively.

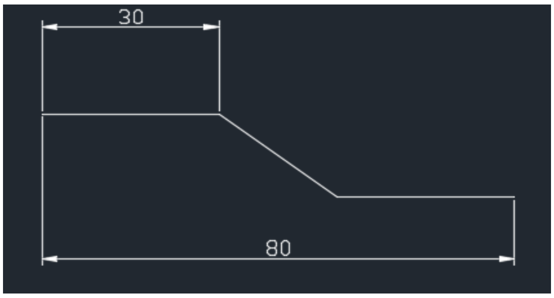

Figure 4: the lined layout of tube

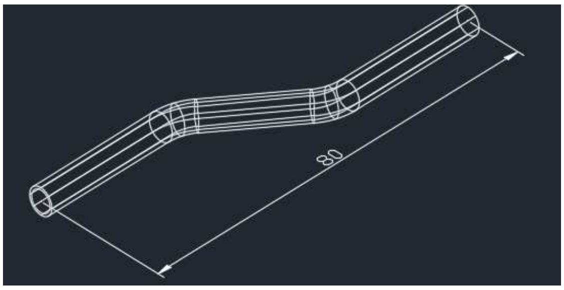

Figure 5: Material Deposition Layers Layout

Table 1: Composite Mixing and Extrusion Percentages in Volume Percentage

Sample	PP%	CNT%
1	99.9	0.1
2	99.8	0.2

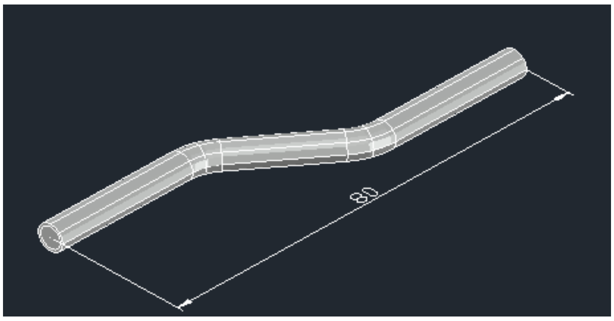

Figure 6: Stereo Lithography Model for Material Deposition

STL (Stereo Lithography) is a record, arrange local to the stereo lithography CAD programming made by 3D Systems STL has a few afterward acronyms, for example, "Standard Triangle Language" and "Standard Tessellation Language.

RESULTS AND DISCUSSIONS

The polymer substance of PP and ABS have taken and the Carbon NANO Tubes added 0.1% and 0.2% to the main substance which is equal to the melting temperature of the polymer and the layers are deposited as per the ratio of input as discussed in the methodology and the whole process has been carried out with good results and the prototypes are shown in the figure 7.

Figure 7: Fabricated Product of Polymer CNT

In the above figure, the polymers PP and ABS had been mixed with 0.1% and 0.2% ratio of CNTs. Spraying and material depositing method and layer formation methods fabricate the tubes to enhance the performance practically and by

simulation. The tubes obtained practically are tested for structural integrity for better optimistic results.

SEM (SCANNING ELECTRON MICROSCOPE) &OM (OPTICAL MICROSCOPE) SURFACE RESULTS OF CNT POLYMER TUBES

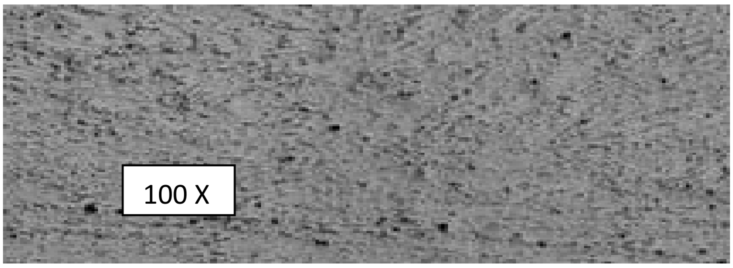

Figure 8: The Surface Topology of Polymer CNT at 100X

The above figure 8 shows the surface topology of the CNT polymer tube can clearly obtain the material composition, the sample extracted to 100X scale to check the mixing of polymer with a little NANO content which can be shown as black spots in the filmy picture.

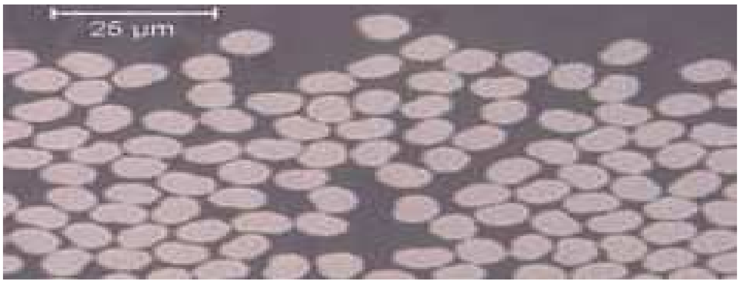

Figure 9: SEM Micro Structural Result of Polymer CNT with 25µm Scale

The above figure 9 shows the SEM micro structural result of the NANO polymer tube at 25µm and the particle depositions shown with even integrity.

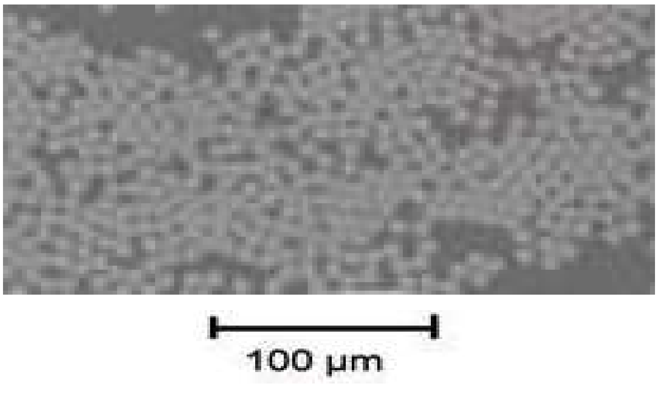

Figure10: SEM Micro Structural Result of Polymer CNT with 100µm Scale

Figure 10 shows the SEM micro structural result of the CNT polymer tube at 100µm where the bonding between the particles shows good in contact.

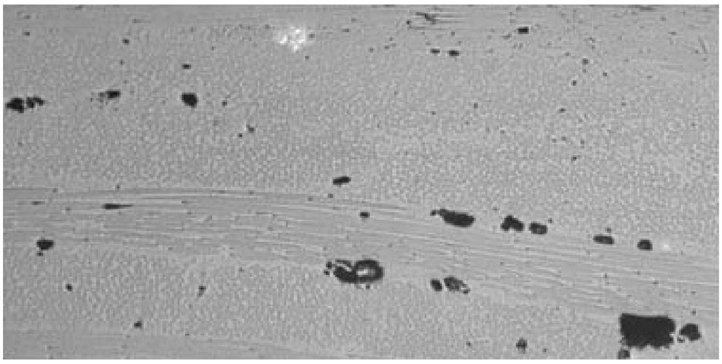

Figure 11: SEM Micro Structural Result of Polymer CNT with 250µm Scale

Figure11 shows the SEM micro structural result of the NANO polymer tube at 250µm where the bonding of particles flow in a stream way of depositing and the air gaps in bonding also shown as layers while depositing.

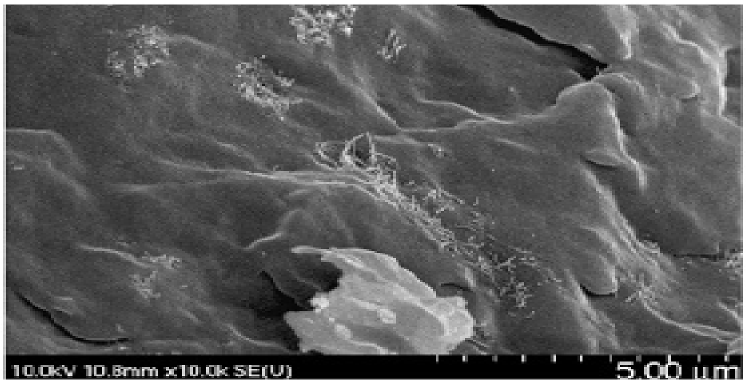

Figure 12: SEM Micro Structural Result of Polymer CNT 500µm Scale

Figure 12 shows the SEM micro structural result of the NANO polymer tube at 500µm where the flow of depositing materials with layers like small molecule attachments, the extracting scale is at low scale value such that it can observe up to a critical extent.

As per the results obtained in the OM and SEM the polymer matrix composites with the metal depositing method in the slow process of 90 minutes in heating, depositing and forming with the combination of PP and ABS in the same aspect ratio, is formed in a proper bonding without getting lashes formation. The integral methods of adding material at certain temperature i.e. 180^{0}C are observed.

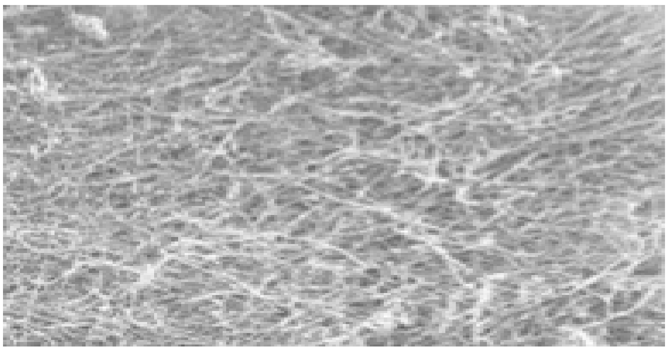

Figure 13: SEM Image of 0.2%CNT of PP with 10 mm Area in Length

MECHANICAL & THERMAL PROPERTIES OF CNT POLYMER TUBES

Table 2: Mechanical Properties of fabricated CNT Polymer Tube

CNT %	MODULUS[GPA]	STRENGTH[MPA]	FAILURE STRAIN%
0.1% add to PP	2.45	109	6.06
0.2% add to PP	2.64	115	6.80
0.1% add to ABS	2.60	113	5.12
0.2% add to ABS	2.73	121	7.52

Table 3: Thermal Properties of Fabricated Polymer Tubes

S. No	Sample	Operating Temperature Range K	Thermal stability K
1	0.1% CNT add to PP	313-393	<500
2	0.2% CNT add to PP	313-413	<500
3	0.1% CNT add to ABS	313-393	<500
4	0.2% CNT add to ABS	313-413	<500

The above tabular form shows the detailed test results of the operating temperature range and thermal stability of 0.1%CNT & 0.2%CNT of PP which is in desirable condition

The above table shows the different values of strength, modulus of elasticity and failure strain of NANO polymer tube at 0.1% & 0.2%percentage NANO particle with respect to PP & ABS. As per the observation from microstructures and mechanical properties, critical gap filling has been done, NANO layers and the strength of PP with 0.2% of CNT had given good result. The SEM image extended up to 500 µm to check the minute gaps in fabrication.

Table 4: Test Results of 0.2 % CNT Poly Propylene Tube

S. NO	Test	Test method	Result	Unit
1	Tensile strength at yield	DIN-53455	41.2	N/mm^2
2	Elongation at break	DIN-53455	390	%
3	Specific gravity	DIN-53479	0.9381	-
4	Shore d hardness	DIN-53505	70.0	-
5	Impact strength	DIN-53453	151.39	mj/mm^2
6	Abrasion resistance	ASTM D-1044	68.4	Mg
7	Breaking strength	DIN-53455	36.19	N/mm^2
8	Compression strength	DIN-534551Q	24.07	N/mm^2
9	Bending strength	DIN-53455	24.89	N/mm^2
10	Co-efficient of friction	DIN-53375		
A	Static		0.14	
B	Kinetic		0.11	
11	Torsion strength at 23^{o}c	DIN-53477	263.63	N/mm^2

The above tabular form shows the test results of PP with 0.2% CNT at different conditions like tensile strength , elongation, specific gravity, co-efficient of friction, bending strength, torsion strength , static & kinetic frictions etc.,

CONCLUSIONS

In a polymer NANO composite, the large surface area of the NANO particles maximizes the extent of polymer/particle interfacial area. Furthermore, in the case of percolating network, the number of contact points between particles increases with decreasing particle size. By observing the mechanical properties of PMC NANO tubes, it is reliable for various applications like automobile, orifice, diagnostics, non corrosive, and paper industries. By observing the mechanical properties by doing tensile, hardness tests and comparing with others and the data are shown in table for validation.

Summary of Results Comparison with another Matrix

By observing the results obtained after adding CNTs to PP, ultimate strength is 115 MPa, tensile strength at yield is 41.2 MPa and the breaking strength is 36.19 MPa , torsion strength at 23^0c is 263 Mpa. When compared with the normal polymer matrix, it is 65,35.4, 29 and 210 MPa, compared with an aluminium matrix with fly ash, it is 122 MPa, 44, 40, 270 MPa respectively. By making the comparison, application replacement of PP with CNT in place of aluminium fly ash matrix has a scope.

Table 5: Considerations for PMC's, MMC's with CNT % NANO Addition

S. No	Type	PMC's	(AL)MMC's	PMC's(CNT) with NANO Addition
1	Molecular bonding	Good	Good	Better
2	Surface smoothness	1.47	2.32	2.78
3	Velocity stream line	Poor	good	Better
4	Heat flux	271	398	303
5	Pressure gradients	1.01	1.76	2.1
6	Manufacturing ability	good	better	Fine

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